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Bubble formation during decompression of andesitic melts

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Abstract

Bubble formation during continuous decompression from ~400 to ~70 MPa was investigated experimentally in hydrous andesitic melts at T = 1030 °C and at an oxygen fugacity (f_{O_2}) of about $\log(f_{O_2}/\text{bar})$ = QFM+1 (QFM: quartz-fayalite-magnetite buffer). Experiments were carried out at variable decompression rates (r), ranging from 0.0005 to 0.1 MPa/s. The samples were directly quenched after decompression, allowing the investigation of the influence of r on the bubble formation. The effect of variable annealing times (t_A) after decompression was also investigated for experiments performed at a decompression rate of 0.1 MPa/s. These samples were annealed for t_A = 0 to 72 h at final pressure (70 MPa) to study changes in vesiculation during magma storage at shallow depths after fast ascent. Backscattered electron (BSE) images of the samples were analyzed to determine bubble number densities (BND).

The BND values increase strongly with increasing r and vary from about $10^{2.2}$ mm^{-3} at 0.0005 MPa/s to about $10^{4.6}$ mm^{-3} at 0.1 MPa/s. After fast decompression (r ~ 0.1 MPa/s), the BND decrease significantly with t_A, i.e., from ~$10^{4.6}$ mm^{-3} at t_A = 0 h to ~$10^{2.9}$ mm^{-3} at t_A = 72 h. A comparison of the derived BND values with recently published experimental data demonstrates the essential role of the decompression path on bubble formation. The BND are higher in experiments with multi- or single-step decompression when compared to continuous decompression. The new data show that H_2O-undersaturated andesitic melts are characterized by 1 to 2 log units higher BND values than H_2O-saturated rhyolitic melts after decompression with the same rate, indicating a strong influence of melt composition on bubble nucleation. This compositional effect is not predicted accurately by existing models and the interpretation of the vesicularity of dacitic to andesitic melts may lead to overestimations of magma ascent rates by about an order of magnitude.

Keywords: Bubble formation, bubble number density, andesite, continuous decompression